A CONCRETE THEATER BALCONY

By I. T. FENNEMAN, '31

An engineer constructing a balcony of the usual type having a steel frame-work has but two major problems confronting him. The first is the erection of the steel skeleton and the second is the placement of the concrete floor slab, neither of which is extremely difficult. However, in building a balcony entirely of concrete without pillars for supporting the central portion, the engineer has a different problem to overcome. He must build the forms sufficiently strong not only to support the weight of the wet concrete but also to prevent them from twisting and sagging. A balcony of the latter type, built for Schine's Ohio Theater at Lima, Ohio, is of interest because it incorporates an 82-ft. concrete girder and because its construction necessitated the erection of special forms. It was originally designed in structural steel with concrete floor slabs but was later redesigned in reinforced concrete to permit quicker construction. It is the third of this design which has been constructed in the United States and the first of this length in Ohio. The seating capacity is approximately 426, including two loge sections.

The balcony is 43x82 ft. and is supported on a main girder beam which spans the full width of the auditorium, being an 82-ft. clear span. This beam not only supports most of the balcony but the mezzanine floor as well. It rests on two columns 22x40 in. having a step-up footer with a 12x12 ft. base. The beam which is 3 ft. 6 in. wide, varies in height from 7 ft. 8 in. to 9 ft. 7 in. and its tee soffit varies in width from 8 ft. 2 in. at mid span to nothing at the ends. The use of tapered tees designed to reduce the dead load was one of the special features of the balcony.

The main or fulcrum beam is intersected at its center by two diagonal tie beams. The three as a whole resemble a large horizontal K whose ends are supported by four columns, two being enclosed in each of the side walls of the theater. The two diagonal beams are 21 in. x 50 in. x 45 ft. A smaller beam was placed between the diagonal ones, as may be seen in the photograph, to reduce the overhang of the cantilever beams.

View showing substructure in place.

A uniform bearing surface was obtained by leveling off the ground which would be directly under the beams, and then covering it with a three-inch layer of stone-sand. Two- and three-inch plank were cut into two-foot lengths and placed side by side in three rows on the stone-sand. The bottom ends of the shores rested on 6 in. x 12 in. timbers which were placed end to end on the planks. One row having been located on the center line of the beam, the other two were laid on opposite sides at a distance of three feet from the former. Under the smaller beams, however, the short planks were deemed unnecessary, the weight being supported by two rows of timbers lying on the stone-sand.

The contractors decided to support the fulcrum and the two tie beams with 5 in. x 8 in. shores placed three feet on centers since the load on the main beam ran over three tons per lineal foot. Another timber of the same size was placed at right angles to the center line of the beams, across the top of each set of three shores for the larger beam and of each set of two for the smaller ones. Pieces of 2 in. x 6 in. plank were scabbed to the shores and cross ties to keep the latter from slipping off. Tongue and grooved flooring $2\frac{1}{2}$ in. thick was nailed directly to the cross ties to form the bottom of the beam.

The main girder was chambered 3 in. at the center to allow for the possible settlement of the sills and for the compression of the formwork. The actual deflection when the forms were removed was scarcely measurable, but the chamber served the purpose of overcoming the optical illusion of sagging.

Studding were toenailed to the horizontal timbers, but since the latter were 3 ft. apart it became necessary to place an additional one between them. The lower ends extended below the flooring so that the two opposite sides might be held together by spiking a cross tie to them, thus preventing the lower sides of the form from bulging to any noticeable extent. Ship-lap sheathing was then nailed to the studding to form the sides of the beams.

The next thing to be considered was the method of bracing the sides and preventing their spreading. Arms were nailed to the extremities of the cross ties and to the studding resting on those ties, at one-third the distance down from the top. Planks were fastened along each side about 2 ft. from the floor. Through them a number of $\frac{3}{4}$-in. bolts, long enough to go through and extend 11 in. beyond each side of the beam, were inserted at 5 ft. intervals. However, the reinforcing bars had to be lowered into place first. After the beams had been brought to the proper level by oak wedges driven under the lower ends of the shores, the structure was cross braced by 2 in. x 6 in. planks spiked on both sides of each set of three shores but in opposite directions. On the smaller beams only one brace was used.

Five cantilever beams, supporting the balcony loading proper, extend from the front of the

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structure up into the fulcrum beam and from the rear of the latter on up to the rear theater wall. Since they are only 14 in. wide and vary from 6 in. to 30 in. in depth, the problem of supporting them was not quite as complex. The bottoms were made of 2-in. x 8-in. planks ripped to the proper width and scabbed together. Adjustable shores were used to support these forms.

The sides of the cantilever beams were built of 2-in. plank. The rise and horizontal run for the lower side of the tiers were laid off on the sides and then cut out. It was considered unnecessary to brace these sides since wire stays were to be used to prevent spreading. However, the beam shores were later braced to the shores supporting the balcony floor with ordinary sheathing.

Another unusual feature of the construction was the form work for the floors or tiers as they are sometimes called. The front of the balcony was constructed with a radius of 102 ft., 6½ in. from the center of the stage. Consequently, the face of the riser and the seats had to be curved in order to be concentric. To make the backs of the risers concentric would not only be quite difficult but would also involve a considerable expenditure of

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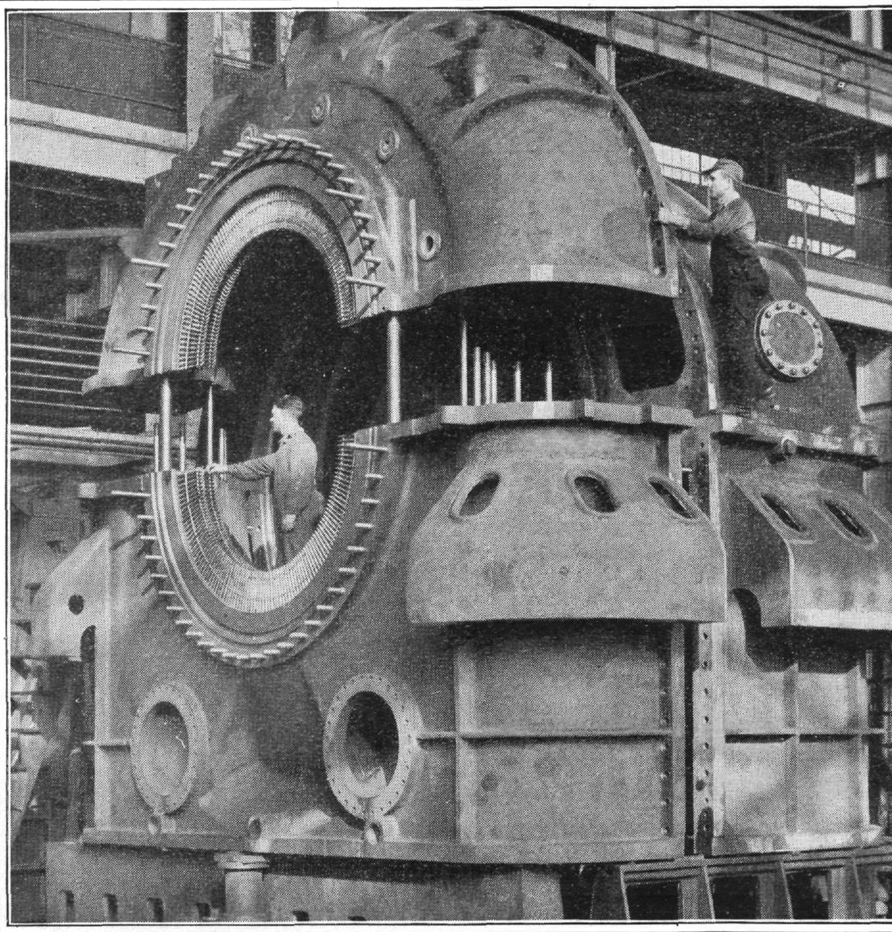

YOUNGER COLLEGE MEN
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The Duke Power Company Turbine-Generators

Where do young college men get in a large industrial organization? Have they opportunity to exercise creative talent? Is individual work recognized?

THE largest steam-turbine generator units to be installed south of the Mason-Dixon line are now being built for one of the most unusual organizations of its kind in the world. The Duke Power Company is famous for the efficiency of its powerplants—and for the fact that its profits are distributed largely to charity.

At a horseshoe bend in the Catawba River in the heart of the Piedmont Carolinas, the Duke Power Company is building a generating plant which, if present plans are carried out, will be the largest of its kind in the southeastern United States. The ultimate capacity will probably be 600,000 horsepower. The first two units, which Westinghouse is now building, each are to have a generating capacity of 55,000 kilowatts. They will develop 150,000 horsepower.

By operating at practically full capacity during the entire 24 hours of the day, letting the company's hydro-electric plants handle variations in the quantity of power required, the new units will reduce current costs to a minimum.

The large jobs go to large organizations. Westinghouse holds a strong appeal for young men of enterprise and genius because it almost daily provides contacts with outstanding developments in all branches of the electric field.

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labor and material, so for this reason they were built without curvature.

A cross tie 4 ft. long was spiked on to the beam sides $7\frac{1}{4}$ in. below the horizontal cuts. The ends of 2-in. x 6-in. joists rested upon them but were supported throughout the remainder of their length by adjustable shores. Two rows of shores were used for each elevation except the first which has three. The first joist in each tier is supported by short 2-in. x 4-in. planks resting on the next lower tier. Sheathing nailed to these particular joists and the 2-in. x 4-in. planks complete the back side form for the risers. To keep the braces from being shoved back, blocks were nailed to the floor just back of them. Again as elsewhere, sheathing was used for flooring.

In constructing the forms for the balcony rail 2-in. x 4-in. studding were used. Ship-lap sheathing was then nailed on to complete the sides. The balcony side or rear side of the rail form was made just high enough for it to be 3 in. above the floor form and at the same time have its top level with the top of the other side. This section was held in position by temporary spreaders and wire stays. Braces from the studding to the ends of the ties on the shores under the rail held the structure in a plumb position.

Following the completion of these phases of the work, the reinforcing rods and steel stirrups were placed in the various beams. Then all stay wires were inserted and tightened by being twisted in the center of the beams with an iron rod. After that, the entire form work was covered with welded wire mesh.

Only the forward part of the balcony forms, including the fulcrum beam, was constructed and then filled with concrete, inasmuch as the forward edge of a mezzanine floor was to be supported by the beam. It was essential that the front half of the balcony and all beams be poured simultaneously since no joints were permissible in the structure.

The problem of holding the forms for the riser faces in position was solved in a unique manner. Planks were spliced together to make them long enough to span the distance from the balcony rail to the top of the fulcrum beam forms. One end was securely fastened to the balcony rail form at the rear. For all risers except the third, which is 16 in. high, $\frac{3}{4}$-in. x 12-in. boards were nailed to 2-in. x 4-in. planks about 2 ft. long. The upper ends of the latter were spiked to the 2-in. x 12-in. planks which were about 5 ft. apart. The correct bend for the risers was determined by plumbing up from a curve marked upon the floors prior to the placement of the wire mesh. Braces nailed to the bottom of the planks prevented the facing board from being shoved back by the force of the wet concrete.

Forms for the forward half of the balcony were erected in approximately three weeks. The concrete for this section having set for twenty-one days all form work was removed.

The architects were P. M. Hulsken and L. T. Strong, and the contractors were Green and Sawyer, all of Lima, Ohio. The redesign was made by R. C. Reese, consulting engineer for Building Products Company, Toledo, Ohio.